and 23 are in independent form and Claims 10 through 24 remain for consideration in this case. Favorable reconsideration of all remaining claims is respectfully requested.

Cancellation of Claims 1 to 9 renders rejection of them moot. Of those claims remaining, numbers 10 through 15 and 19 through 23 were rejected as anticipated under 35 U.S.C. § 102(e) by U.S. Patent No. 6,075,799 (Uchida, et al.). Claims 17, 18, 23, and 24 were rejected under 35 U.S.C. § 103(a) as being obvious over the Uchida Patent.

Finally, Claim 16 was rejected as being obvious over the Uchida Patent taken in conjunction with U.S. Patent No. 4,063,189 (Scifres, et al.).

As set forth in amended Claim 10, applicant's invention is a laser that comprises a first region with a first waveguide that includes a first diffraction grating, and a second region with a second waveguide that includes a second diffraction grating. A phase controlling region has a third waveguide and includes control means for controlling an effective refractive index of the third waveguide. The phase controlling region, the first region and the second region are serially coupled in order along a light propagation direction in the laser. These elements are constructed such that a coupling coefficient of the first region adjacent the phase controlling region is smaller than a coupling coefficient of the second region. Further, the first and second diffraction gratings have a common value of pitch.

Antecedent basis for amendments made to Claim 10, as well as those to Claims 19, 20, and 23, is found at page 11, line 27 through page 12, line 4 of the specification as filed.

Thus, a notable feature of the subject invention as set forth in Claim 10 is that two regions having different coupling coefficients are provided in series with a phase

controlling region such that the region having the smaller coupling coefficient is adjacent the phase controlling region. The diffraction gratings of the two regions nevertheless have a common value of pitch. The different coupling coefficients of the regions result from differentiating the depths of the diffraction gratings. Therefore, the present invention provides the advantage that the return light from the phase controlling region is increased, and through the control of the phase controlling region modulation of an oscillation mode can be effectively and stabily accomplished.

It is respectively submitted that the Uchida Patent neither discloses nor suggests Applicant's invention as set forth in Claim 10. More particularly, in the embodiment of the Uchida invention referred to in the Official Action and described at column 28, the Uchida device is a semiconductor laser which has a phase controlling region and a DBR region that includes ten grading regions with gratings 3207 of ten different pitches. These pitches range from 325 nm to 328.6 nm with intervals of 0.4 nms therebetween. Thus, it is submitted, that the Uchida Patent does not disclose or suggest a device such as is claimed having two diffraction gratings that have the same value of pitch but different coupling coefficients.

Applicant wishes to make reference to the work "Semiconductor Laser and Light Integrated Circuit" published by Ohmsha Limited (1984) at page 327, (a copy of portions of which is enclosed), an English language translation of which reads:

> One example of wavelength dependency of reflection factor R is shown in Fig. 11 · 18. At a point of $\beta = \beta_0 = q \ \pi / \ \Lambda$, the reflection factor is maximal. Wavelength, $\lambda_\beta = 2 \pi n_{eq/} \beta_{01}$, which corresponds to β_{01}, is usually called Bragg wavelength. When a loss of the medium α is zero, the reflection factor R_0 at $\lambda = \lambda_\beta$ gets simple and is obtained by $R_0 = \tanh^2 \kappa L_B$ (11 · 48). The bigger the coupling coefficient κ and the longer length L_B of the distributed reflector gets, the bigger the reflection factor R_0 becomes.

In the above description the pitch of the diffraction grating (distributed reflector) is indicated by Λ. Thus, pitch of the diffraction grating is a parameter that determines the wavelength (Bragg wavelength) at which the reflection factor is maximum. In contradistinction, the coupling coefficient κ is a parameter that determines the reflection factor R_0 at the Bragg wavelength. Thus, the pitch of the grating and the coupling coefficient are completely different.

According to the subject invention, the region having the smaller coupling coefficient, namely the region where a reflection factor is smaller at the same wavelength, is provided adjacent the phase controlling region. With such structure, the control of the phase controlling region of the modulation of the device can be made larger.

Therefore, Applicant again submits the subject invention is neither anticipated nor rendered obvious by Uchida Patent.

As set forth in amended Claim 19, Applicant's invention is a method for driving a laser comprising the step of preparing the laser essentially as defined in Claim 10. Claim 19 additionally includes the step of changing a current injected into or a reverse voltage applied to the phase controlling region of the laser to change at least one of a polarization mode and a wavelength of light output from the laser. It is respectfully submitted that, for the reasons set forth with respect to Claim 10, the Uchida Patent neither anticipates nor renders obvious Applicant's invention as set forth in Claim 19.

Amended Claim 20 is directed to a light transmitter comprising a laser, again essentially as defined by amended Claim 10. The light transmitter further includes control means for controlling light output from the laser in accordance with a transmission signal, and a mode selector for selecting a component of a desired mode from the light output from the laser.

Therefore, it is submitted that, for the reasons set forth with respect to amended Claim 10, the Uchida Patent neither anticipates nor renders obvious Applicant's invention as set forth in amended Claim 20.

As set forth in amended Claim 23, Applicant's invention is an optical communication system for communicating over a light transmission line that transmits a signal from a transmitter side to a receiver side. The system includes a light transmitter for transmitting light of a signal through the light transmission line that comprises a laser, essentially as defined in amended Claim 10, along with control means and a mode selector essentially as defined in amended Claim 20. The communication system further includes a receiver for receiving and detecting an intensity modulated signal transmitted from the laser through the light transmission line.

Accordingly, it is again submitted that the Uchida Patent can neither anticipate nor render obvious Applicant's invention as set forth in amended Claim 23.

The Scifres Patent relates to a semiconductor laser that has cleaved faces. However, it is respectfully submitted that this reference does not disclose the use of two diffraction gratings having different coupling coefficients. Therefore, it is submitted that the Scifres Patent cannot supply the teachings missing from the Uchida Patent such as would render any of Applicant's claims obvious.

The claims in the subject application other than those discussed in detail above are each dependent from one or more of those independent claims and are, therefore, believed to be patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual reconsideration of the patentability of each on its own merits is respectfully requested.

In view of the foregoing amendments and remarks, applicant respectfully requests favorable consideration and early passage to issue of the present application.

Applicant's undersigned attorney may be reached in our New York Office by telephone at (212) 218-2100. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO SPECIFICATION

The paragraph starting at page 13, line 5 and ending at page 13, line 24, was replaced with the following:

--The operation of the first embodiment will be described. When a forward bias is applied across the first electrode 10 and the third electrode 12, oscillation of the DFB laser occurs above a [cirtain] certain current amount. In this case, the circulation phase of light oscillated in the cavity satisfies the oscillation condition. Here, the circulation phase is a phase shift that the light shows when the light circulates once in the cavity. In this state, when a current is injected into the phase adjusting region 23 across the second and third electrodes 11 and 12 to change the effective refractive index of the waveguide in this region 23, the phase will be changed in light reflected by the reflective layer 14 and returning to the DFB laser region 22. As a result, the oscillation wavelength prior to the current injection into the region 23 comes to deviate from the circulation-phase condition and light thereat ceases. Thus, the oscillation mode turns to another wavelength or polarization mode that satisfies the circulation-phase condition.--

The paragraph starting at page 16, line 14 and ending at page 17, line 5 was replaced with the following paragraph.

--The operation of the second embodiment will be described. In this embodiment, when a current injected into the portion of the DFB laser region 120 directly adjacent to the phase adjusting region 121 is decreased, the influence of light returning

from the phase adjusting region 121 is effectively imparted to the oscillation mode of the laser. Thus, the second embodiment can be operated similarly to the first embodiment, even though no diffraction gratings with different coupling coefficients [is] <u>are</u> formed in the laser. If only such polarization switching operation is desired, the DFB laser region 120 only needs to be divided into two regions. However, since the DFB laser region 120 is divided into three regions in the second embodiment, the oscillation wavelength can also be readily controlled when amounts of currents injected into the two regions under the two electrodes 10-1 and 10-2 on the side of the antireflection layer 113 are varied, i.e., uneven current injection is performed.--

VERSION WITH MARKINGS TO SHOW CHANGES MADE TO CLAIMS

10. (Amended) A laser comprising:

a first region with a first waveguide, said first waveguide including a first diffraction grating;

a second region with a second waveguide, said second waveguide including a second diffraction grating; and

a phase controlling region with a third waveguide, said phase controlling region including control means for controlling an effective refractive index of said third waveguide[, and]; said phase controlling region, said first region and said second region being serially coupled along a light propagation direction in this order, and being constructed such that a coupling coefficient of said first region adjacent to said phase controlling region [being set] is smaller than a coupling coefficient of said second region, and said first and second diffraction gratings have a common value of pitch.

19. (Amended) A method for driving a laser, said method comprising ~~the steps of:~~

preparing a laser including:

a first region with a first waveguide, said first waveguide including a first diffraction grating;

a second region with a second waveguide, said second waveguide including a second diffraction grating; and

a phase controlling region with a third waveguide, said phase controlling region including [phase] control means for controlling an effective refractive index of said third waveguide[, and]; said phase controlling region, said first region and said second region being serially coupled [to each other] along a light propagation direction in this order, and being constructed such that [light to said first region from said phase controlling region is enlarged relatively to light to said phase controlling region from said first region; and] <u>a coupling coefficient of said first region adjacent to said phase controlling region is smaller than a coupling coefficient of said second region, and said first and second diffraction gratings have a common value of pitch; and</u>

changing a current injected into or a reverse voltage applied to the phase controlling region to change at least one of a polarization mode and a waveguide of light output from the laser.

20. (Amended) A sight transmitter comprising:

a laser including:

a first region with a first waveguide, said first waveguide including a first diffraction grating;

a second region with a second waveguide, said second waveguide including a second diffraction grating; and

a phase controlling region with a third waveguide, said phase controlling region including [phase] control means for controlling an effective refractive

index of said third waveguide[, and]; said phase controlling region, said first region and said second region being serially coupled [to each other] along a light propagation direction in this order, and being constructed such that [light to said first region from said phase controlling region is enlarged relatively to light to said phase controlling region from said first region;] a coupling coefficient of said first region adjacent to said phase controlling region is smaller than a coupling coefficient of said second region, and said first and second diffraction gratings have a common value of pitch;

control means for controlling light output from said laser in accordance with a transmission signal; and

a mode selector for selecting a component of a desired mode from the light output from said laser.

23. (Amended) An optical communication system for communicating over a line transmission line that transmits a signal from a transmitter side to a receiver side, said system comprising:

a light transmitter for transmitting light of a signal through the light transmission line including:

a laser including:

a first region with a first waveguide, said first waveguide including a first diffraction grating;

a second region with a second waveguide, said second waveguide including a second diffraction grating; and

a phase controlling region with a third waveguide, said phase controlling region including [phase] control means for controlling an effective refractive index of said third waveguide[, and]; said phase controlling region, said first region and said second region being serially coupled [to each other] along a light propagation direction in this order, and being constructed such that [light to said first region from said phase controlling region is enlarged relatively to light to said phase controlling region from said first region;] <u>a coupling coefficient of said first region adjacent to said phase controlling region is smaller than a coupling coefficient of said second region, and said first and second diffraction gratings have a common value of pitch;</u>

control means for controlling light output from said laser in accordance with a transmission signal; and

a mode selector for selecting a component of a desired mode from the light output from said laser; and

a receiver for receiving and detecting an intensity-modulated signal transmitted from the laser through the light transmission line.

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半導体レーザと光集積回路

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の変化を見ると，出力導波路の幅 W_e が $W_e=3\,\mu$m より $\pm1\,\mu$m 程度変動しても，90%以上の結合効率が得られることがわかる．一方，図11・16は，C_{out} と軸ずれ量 S との関係を出力導波路の組成 λ_g と厚さ t をパラメータにして示しており[30]，$W_e=W_a$ を仮定している．t を変えると界分布の中心が y 軸上で動くため，C_{out} が最大となる S の値も変化する．また，厚さ t が設定値より ±20% 程度ずれても $C_{out}\sim95$% の光結合が得られる．さらに，C_{out} の値は導波路のコアの組成 λ_g の変動にあまり依存しないことがわかる．

このように BJB 構造は，導波路の製作誤差の許容度がかなり緩和された構造となっており，比較的容易に高効率の光結合が実現できる構造といえよう．

11・4・3 LOC 構造の結合特性

前節で得た結合効率の式は LOC 構造の結合特性の検討にも用いられる．LOC 構造は，図11・7からわかるように，活性導波路と出力導波路の間で界分布の中心を一致させることはむずかしく，高い結合効率は期待できない．活性導波路の厚さを 0.06 μm 程度に薄くすれば，界分布の中心が出力導波路層のほうへシフトして，95%以上の結合効率が得られる[53]．その反面，発振しきい値が著しく増加してしまう．この構造の最適の結合効率は50%程度と考えられている[30]．

11・5 分布反射器 (DBR) の解析

周期構造（グレーティング）をレーザ反射機構として利用する分布反射器 (DBR) レーザや分布帰還型 (DFB) レーザは，次章で述べるように優れた性能を有するレーザとして注目されている．ここでは，この周期構造からのブラック反射の特性を解析するための手法を概説する．

解析の基礎にする波動方程式は，

$$\left\{\begin{array}{l}\dfrac{\partial^2}{\partial z^2}E+k^2E=0 \qquad (11\cdot28)\\ k^2=k_0{}^2\cdot n^2-jk_0n\alpha \qquad (11\cdot29)\end{array}\right.$$

ここで，$k_0(=2\pi/\lambda)$ は波数，n は屈折率，α は光電力の損失係数で，通常の場合には $\alpha\ll k_0n$ が成り立つ．

屈折率は，z 方向に周期 Λ で周期的に変化しており

$$n(z)=n_0+(\Delta n)\cos(2\pi z/\Lambda+\varphi) \qquad (11\cdot30)$$

で与えられる．このような周期構造を有する空間では，z 方向の正方向に伝搬する前進波と負の方向に伝搬する後進波は，ブラック回折のために結合している．そこで電磁界は，振幅が z の関数となった二つの平面波の和で表し

$$E(z)=R(z)e^{-j\beta_0 z}+S(z)e^{j\beta_0 z} \qquad (11\cdot31)$$

q 次のブラック反射とすると，周期構造の波数 K は $2q\pi/\Lambda$ で，ブラック回折するためには，波数の保存則として

$$-\beta_0+2q\pi/\Lambda=\beta_0 \quad (q:1,2,3\cdots) \qquad (11\cdot32)$$

が成り立つ必要がある．したがって $\beta_0=q\pi/\Lambda$ である．

周期構造内の電磁界は，厳密には無限次の回折成分まで展開して表すが，q 次のブラッグ条件を満たす波長の近傍についてみると，着目する q 次の回折以外の成分は，振幅が著しく小さく無視できる．

式（11・30）を式（11・29）に代入し，$(\Delta n)^2$，$\alpha\cdot\Delta n$ の項が無視できるため

$$k^2\simeq\beta^2-j\alpha\beta+4\kappa\beta\cos(2\pi z/\Lambda+\varphi) \tag{11・33}$$

ここで結合係数 κ は

$$\kappa=(k_0\cdot\Delta n)/2 \tag{11・34}$$

で定義される．さらに，$\beta=k_0\cdot n_0$ である．

式（11・31）を式（11・28）に代入すると

$$\{R''-2j\beta_0R'+(k^2-\beta_0{}^2)R\}e^{-j\beta_0z}+\{S''+2j\beta_0S'+(k^2-\beta_0{}^2)S\}e^{+j\beta_0z}=0 \tag{11・35}$$

で，ここで $R(z)$，$S(z)$ は z に対しゆるやかにしか変化しないため，R''，S'' を無視する．式（11・33）を代入し，それぞれ $e^{+j\beta_0z}$ および $e^{-j\beta_0z}$ を両辺に掛けて z について積分すると，R と S についての結合方程式として，

$$\left\{\begin{aligned}&-R'-(\alpha/2+j\delta)R=j\kappa e^{-j\varphi}S\\&S'-(\alpha/2+j\delta)S=j\kappa e^{j\varphi}R\end{aligned}\right. \tag{11・36}$$

を得る．ここで δ は $(\beta^2-\beta_0{}^2)/2\beta_0\simeq\beta-\beta_0$ で β_0 からの離調を示し，$\delta=\pi(2n_{eq}/\lambda-q/\Lambda)=2n_{eq}\pi(1/\lambda-1/\lambda_B)$ で与えられる．λ_B はブラッグ波長，n_{eq} は導波路の等価屈折率である．

式（11・36）は定係数線形微分方程式で，指数関数形の解を有することは明らかで，r_1，r_2，s_1 および s_2 を定数とすると，一般解は

$$\left.\begin{aligned}R(z)&=\mathrm{r}_1e^{\gamma z}+\mathrm{r}_2e^{-\gamma z}\\S(z)&=\mathrm{s}_1e^{\gamma z}+\mathrm{s}_2e^{-\gamma z}\end{aligned}\right\} \tag{11・37}$$

式（11・37）を式（11・36）に代入すると，次の四つの関係が得られる．

$$\left.\begin{aligned}&\left(-\gamma-\frac{\alpha}{2}-j\delta\right)\mathrm{r}_1=j\kappa e^{-j\varphi}\mathrm{s}_1,\quad \left(\gamma-\frac{\alpha}{2}-j\delta\right)\mathrm{r}_2=j\kappa e^{-j\varphi}\mathrm{s}_2\\&\left(\gamma-\frac{\alpha}{2}-j\delta\right)\mathrm{s}_1=j\kappa e^{j\varphi}\mathrm{r}_1,\quad \left(-\gamma-\frac{\alpha}{2}-j\delta\right)\mathrm{s}_2=j\kappa e^{j\varphi}\mathrm{r}_2\end{aligned}\right\} \tag{11・38}$$

これらの式より γ は

$$\gamma^2=\left(\frac{\alpha}{2}+j\delta\right)^2+\kappa^2 \tag{11・39}$$

の分散関係を満足する．

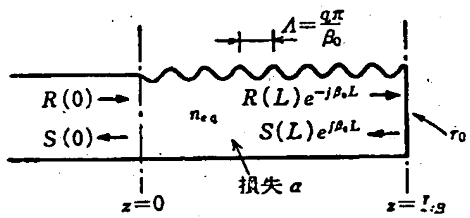

図 11・17．一端に反射面を有する周期構造．入射光を $R(0)$，反射光を $S(0)$，長さ L_B

次に，図11・17のように，周期構造の終端に反射率 r_0 の反射面がある，長さ L_B の分布反射器内の z 方向の電磁界分布と分布反射器からの反射率の式を導く．まず，前進波の振幅 $R(z)$ は式（11・37）より

$$R(z)=R(0)\frac{e^{\gamma z}+(\mathrm{r}_2/\mathrm{r}_1)e^{-\gamma z}}{1+\mathrm{r}_2/\mathrm{r}_1} \tag{11・40}$$

で与えられる．$\mathrm{r}_2/\mathrm{r}_1$ の値は，$z=L_B$ の点での境界条件

$$r_0 R(L_B) e^{-j\beta_0 L_B} = S(L_B) e^{j\beta_0 L_B} \qquad (11\cdot41)$$

と式 (11・38) から簡単に導出される．これを式 (11・40) に代入すると，$R(z)$ として

$$R(z) = R(0)\frac{\gamma\cosh\gamma(z-L_B) - \{(\alpha/2+j\delta)+j\kappa r_0 e^{-j(\varphi+2\beta_0 L_B)}\}\sinh\gamma(z-L_B)}{\gamma\cosh\gamma L_B + \{(\alpha/2+j\delta)+j\kappa r_0 e^{-j(\varphi+2\beta_0 L_B)}\}\sinh\gamma L_B} \qquad (11\cdot42)$$

同様に $S(z)$ は

$$S(z) = R(0)\frac{\gamma r_0 e^{-j2\beta_0 L_B}\cosh\gamma(z-L_B) + \{(\alpha/2+j\delta)r_0 e^{-j2\beta_0 L_B}+j\kappa e^{j\varphi}\}\sinh\gamma(z-L_B)}{\gamma\cosh\gamma L_B + \{(\alpha/2+j\delta)+j\kappa r_0 e^{-j(\varphi+2\beta_0 L_B)}\}\sinh\gamma L_B} \qquad (11\cdot43)$$

で与えられる．

一方，$z=0$ の点で分布反射器を見たときの反射率 r は，式 (11・43) より

$$r = \frac{S(0)}{R(0)} = \frac{\gamma r_0 e^{-j(2\beta_0 L_B+\varphi)}\cosh\gamma L_B - \{(\alpha/2+j\delta)r_0 e^{-j(2\beta_0 L_B+\varphi)}+j\kappa\}\sinh\gamma L_B}{\gamma\cosh\gamma L_B + \{(\alpha/2+j\delta)+j\kappa r_0 e^{-j(2\beta_0 L_B+\varphi)}\}\sinh\gamma L_B} e^{j\varphi} \qquad (11\cdot44)$$

となり，また通常振幅 $|r|$ と位相 ϕ を用いて

$$\equiv |r| e^{-j\phi} \qquad (11\cdot45)$$

で表す．ここで，φ は式 (11・30) よりわかるように，$z=0$ の点で周期構造が始まる位相を示しており，$2\beta_0 L_B+\varphi$ は終端の反射面 r_0 が正弦波のどの位相の位置につくられているかを示している．したがって，分布反射器の反射率は終端反射面の位置に依存して，その絶対値 $|r|$ が変化するばかりでなく位相遅れ ϕ も変化することがわかる．実際のレーザでは，へき開により反射面 r_0 をつくっており，また，周期構造の周期が 200～300 nm と小さいため，反射面の位置を制御することはきわめてむずかしく，チップごとに発振特性のバラツキが生ずる原因となる．そこで，端面反射の影響を除くための構造上の工夫が必要となる．

次に分布反射器の反射特性の基本的性質について述べる．まず，終端の反射面がない場合に，反射率は $\varphi=2q\pi$ (q : 整数) として式 (11・44) より下式となる．

$$r = \frac{-j\kappa\tanh\gamma L_B}{\gamma+(\alpha/2+j\delta)\tanh\gamma L_B} \equiv |r| e^{-j\phi} \qquad (11\cdot46)$$

光電力の反射係数 $R=|r|^2$ で表すと

$$R = \frac{\kappa^2\tanh^2\gamma L_B}{(\gamma+\alpha/2\tanh\gamma L_B)^2+\delta^2\tanh^2\gamma L_B} \qquad (11\cdot47)$$

となる．

反射率 R の波長依存性の一例を図 11・18 に示す[12]．$\beta=\beta_0=q\pi/\Lambda$ の点で反射率が最大となる．β_0 に対応する波長 $\lambda_B=2\pi n_{eq}/\beta_0$ は通常，ブラッグ波長と呼ばれている．媒質の損失 α が 0 であるとき，$\lambda=\lambda_B$ での反射率 R_0 は簡単になり

$$R_0 = \tanh^2\kappa L_B \qquad (11\cdot48)$$

で与えられる．結合係数 κ が大きいほど，分布反射器の長さ L_B が長いほど，反射率 R_0 が大きくなる．一方，反射特性の鋭さ

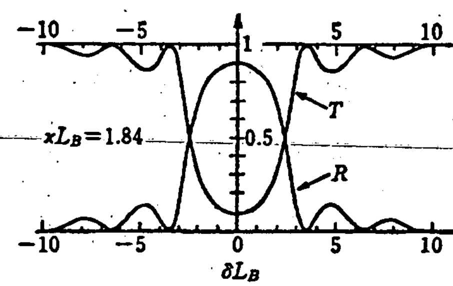

図 11・18　分布反射器の反射係数と透過係数の波長特性．長さ L_B, $r_0=0$ の分布反射器，δ は $\pi(2n_{eq}/\lambda-q/\Lambda)$ で，ブラッグ波長 $\lambda_B(=n_{eq}\Lambda/q)$ からの離調を表す．(Yariv，中村による[12])

を評価するため，導波路の損失を無視してブラッグ波長の両側の反射率の最初に0となる点の間の波長幅 $\Delta\lambda$ を近似的に求めると

$$\frac{\Delta\lambda}{\lambda_B}\cong\left(\frac{\lambda_B}{n_{eff}}\right)\Big/\left(\frac{L_B}{\sqrt{1+(\kappa L_B/\pi)^2}}\right)\equiv\frac{\lambda_B}{2n_{eff}L_{eff}} \tag{11·49}$$

となる．L_{eff} は周期構造の有効的な長さで，κL_B が大きく，光が分布反射器の入口付近で反射されて

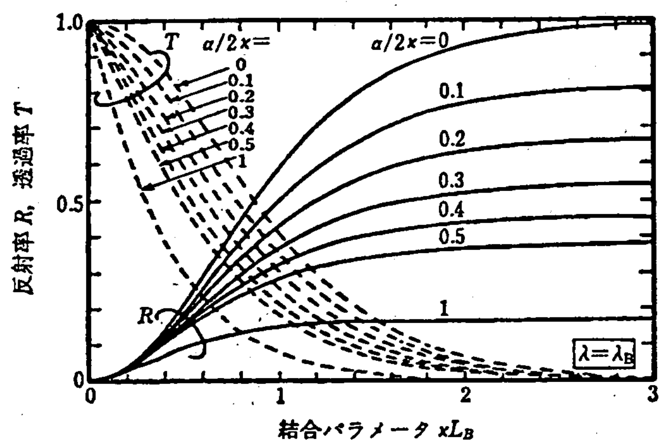

図 11·19　ブラッグ波長における分布反射器の反射係数と透過係数と結合パラメータ κL_B との関係．$r_0=0$，$\lambda=\lambda_B$，パラメータ：α/κ（宇高および末松，荒井，岸野による[13)54)]）

内部へ入ってゆかないときには，小さくなる．

式 (11·49) より，結合係数 κ が大きく，$(\kappa L_B/\pi)^2\gg 1$ のときには，反射特性の幅は κ の値で決まり，分布反射器の長さ L_B にほとんど依存しないことがわかる．また，κ の値を適当に小さな値にすれば（たとえば $\kappa L_B\sim 1$），光電力が分布反射器全体に分布して，長さ L_B を大きくするほど $\Delta\lambda$ が狭くなって波長選択性が鋭くなる．ただし，これは導波路の損失が少ない場合であって，損失が大きくなると光が減衰して分布反射器が有効に作用しないため波長選択性は鈍化する．

図 11·19 に，パラメータを $\alpha/2\kappa$ として，端面に反射鏡のない（$r_0=0$）ブラッグ波長の点における分布反射器の電力反射係数 R および透過係数 T と結合パラメータ κL_B との関係を示す[13)54)]．

11·6　グレーティング結合器

グレーティングは導波モードと放射モードとの結合器としても作用し，図 11·20 に示すように，光電力を導波路に垂直な方向へ取り出すことができる．光線1と光線2は，下式を満足するとき互いに位相が一致し，導波モードの光電力の一部が θ の方向に放射される．

$$n_2\cos\theta=n_{eq}-q\frac{\lambda}{\Lambda} \tag{11·50}$$

ここで，q は整数，n_{eq} は導波路の等価屈折率，λ は波長である．

光は上方向だけでなく基板側へも放射され，$n_2=n_3$ のときは，その比率は1対1となり，$n_2<n_3$ の

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半導体レーザと光集積回路

昭和59年4月25日　第1版第1刷発行
昭和62年3月20日　第1版第2刷発行

OHM・OHM・OHM
編著者承認
検印省略

編著者　末松安晴
発行者　株式会社 オーム社
代表者　種田則一
発行所　株式会社 オーム社
郵便番号　101
東京都千代田区神田錦町3-1
振替　東京 6-20018
電話　03(233)0641(大代)

Printed in Japan

印刷　壮光舎印刷　製本　大進堂
落丁・乱丁本はお取替えいたします

ISBN 4-274-03022-9